This document was prepared under a contract with the Office of Technology Assessment, Congress of the United States, for the assessment on Basic Research for the 1990s. The conclusions are those of the author. This document does not necessarily reflect the analytical findings of the OTA, the Advisory Group, or the Technology Assessment Board.

Task Force on Science Policy: A Window on the Federal Funding and Management of Research

Patrick Hamlett
Science, Technology and Society Program
Cornell University

Prepared under contract to the Office of Technology Assessment
Revised October 1990

DRAFT – DO NOT CITE, QUOTE, OR REPRODUCE

J952-55

I. Introduction

The shaping of national science research policy places a significant responsibility upon the United States Congress, which is answerable to the American people for the quality of its stewardship in this crucial area. Because decisions about science have impacts years and decades after they are taken, the Congressional burden is all the greater, since not only are today's constituents and voters affected by what Members of Congress do, the health and vitality of the scientific enterprise in America -- along with all that scientific health and vitality means to the economy, the environment, and public health -- for many years into the future will be framed by legislative decision made now.

For a decision making body such as the Congress, access to highly qualified external expertise is essential to the responsible completion of these duties. However, as every observer of Congress knows, the concerns, goals, and even language used by external experts often differs from the concerns and goals of legislators. Both sets of actors come from very different institutional and organizational settings. Achieving authentic and useful communications between both groups can be difficult. Analyzing such interactions can shed light on how to improve communications, remove obstacles, and improve the quality of legislative decisions.

The goal of this report is to discuss an array of interactions between noted scientists, science policy experts, and Members of Congress over the course of several hearings of the Task Force on Science Policy, Committee on Science, Space, and Technology, U.S. House of Representatives, in 1985 an

1986. This remarkable effort at policy analysis brought dozens of scientists, historians, philosophers, corporate representatives, federal regulatory agencies, and many others, before the Task Force for intensive questioning. The record of their discussions offers a unique window on the quality and tenor of contacts between the science community and elected representatives. As the Congress considers the nation's research needs and priorities into the twenty-first century, the Task Force hearings offer an important baseline for future policy making.

The OTA staff posed five questions about the interactions and exchanges captured in a sample of six of the Task Force hearings, and using a nineteen-item theoretical framework [see Methological Appendix], I have sought to display the central tendencies of witnesses' and Members' concerns and interests, the points of agreement and disagreement between witnesses and Members, derived from their testimony, formal statements, and question-and-answer responses.

II. Findings

A. Question One: What have been the profiles of the research areas supported by the major Federal agencies?

1. Major concerns expressed by witnesses

A single thematic measure ("Multidisciplinary mission programs") was used to measure how often witnesses and Members referred to, commented upon, or indicated an interest in this question. As can be seen in the accompanying table and graph, witnesses spoke to this theme much more frequently than did Members.

Put OTA Summary Table 1 and OTA Summary Graph 1 approximately here

Those witnesses who discussed multidisciplinary mission programs often pointed to their beneficial impacts on both infrastructural costs and investigator education, rather than to the specific research output. One witness, discussing funding for multidisciplinary projects, was quite explicit:

> ...one of the major functions that block or center grants have served in my particular career have been to produce what was often awful research -- I mean just awful research -- but wonderful education. One of the great things that can happen in a block or center grant is that a group of investigators who are in some deep-seated sense fundamentally incompetent to work in a particular area of importance are brought together, they work in the area, and what comes out of it is a process of education which is almost, in my experience, unachievable by any other process[1].

Thus, witnesses asserted that, in addition to allowing the pooling of resources for expensive equipment and other infrastructure, multidisciplinary projects encourage a level of communication and up-grading of skills arguably unavailable anywhere else. And, they claimed, these advantages outweigh the admittedly often lower quality of research product such programs produce.

2. Major concerns expressed by Members

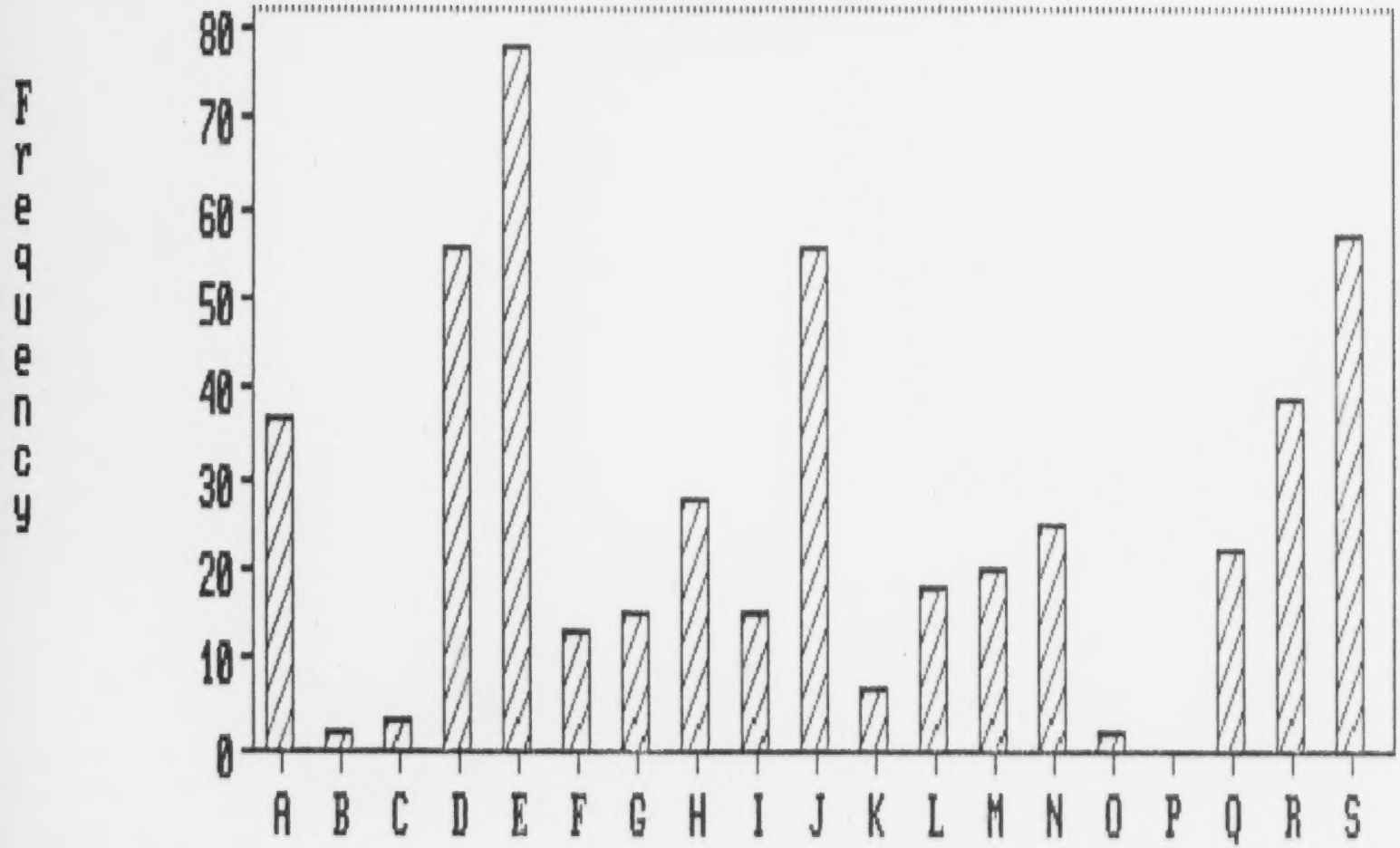
Members' only comments about multidisciplinary programs were questions about how such programs help with infrastructural costs, and how they can best and most efficiently be organized.

OTA SUMMARY TABLE 1
Witnesses' Formal Statements

TABLES	A	B	C	D	E	F	G	H	I	J	K	L
OTA 1	5	0	2	0	23	5	5	25	10	0	0	0
OTA 3	14	0	1	45	4	6	5	1	1	10	3	1
OTA 5	7	0	0	2	2	2	0	1	2	22	0	1
OTA 7	2	0	0	4	2	0	1	1	0	4	0	2
OTA 9	9	0	0	1	47	0	1	0	2	19	0	4
OTA 11	0	0	0	3	0	0	2	0	0	1	0	0
TOTALS	37	2	3	56	78	13	15	28	15	56	7	10
PERCENT	0.07	0.00	0.00	0.11	0.15	0.02	0.03	0.05	0.03	0.11	0.01	0.02

M	N	O	P	Q	R	S
0	0	0	0	6	4	0
15	16	0	0	50	1	16
1	4	2	0	9	31	38
0	3	0	0	0	0	0
3	1	0	0	3	3	3
0	1	0	0	4	0	0
20	25	2	0	22	39	57
0.04	0.05	0.00	0	0.04	0.07	0.12

OTA SUMMARY GRAPH 1
WITNESSES' FORMAL STATEMENTS



OTA 1, 3, 5, 7, 9, 11

Put OTA Summary Table 2 and OTA Summary Graph 2 approximately here

---

3. Points of agreement/disagreement between witnesses and Members

The low level of Members' interest is perhaps the most notable finding here. Given the relatively low level of systematic interest displayed by Members in this theme (mentioned only 6 times), when compared to the greater concern of witnesses (discussed 37 times), little disagreement in perspective was evidenced between the two groups in these hearings. The greater degree of witnesses' concern accords well with the high level of concern they expressed on related themes, such as "Efficiency vs. Inefficiency" (11% of comments) and "Infrastructure Problems" (12% of comments), especially since they regularly cited beneficial impacts in both these areas as part of the rationale for supporting multidisciplinary mission programs.

B. Question Two: What data and analytical tools are useful in characterizing the goals, priorities, and outcomes of basic research? Are commonly used categories, such as civilian vs. military, big vs. little science, and centers vs. individual projects, adequate (or even useful) for describing the Nation's research activities?

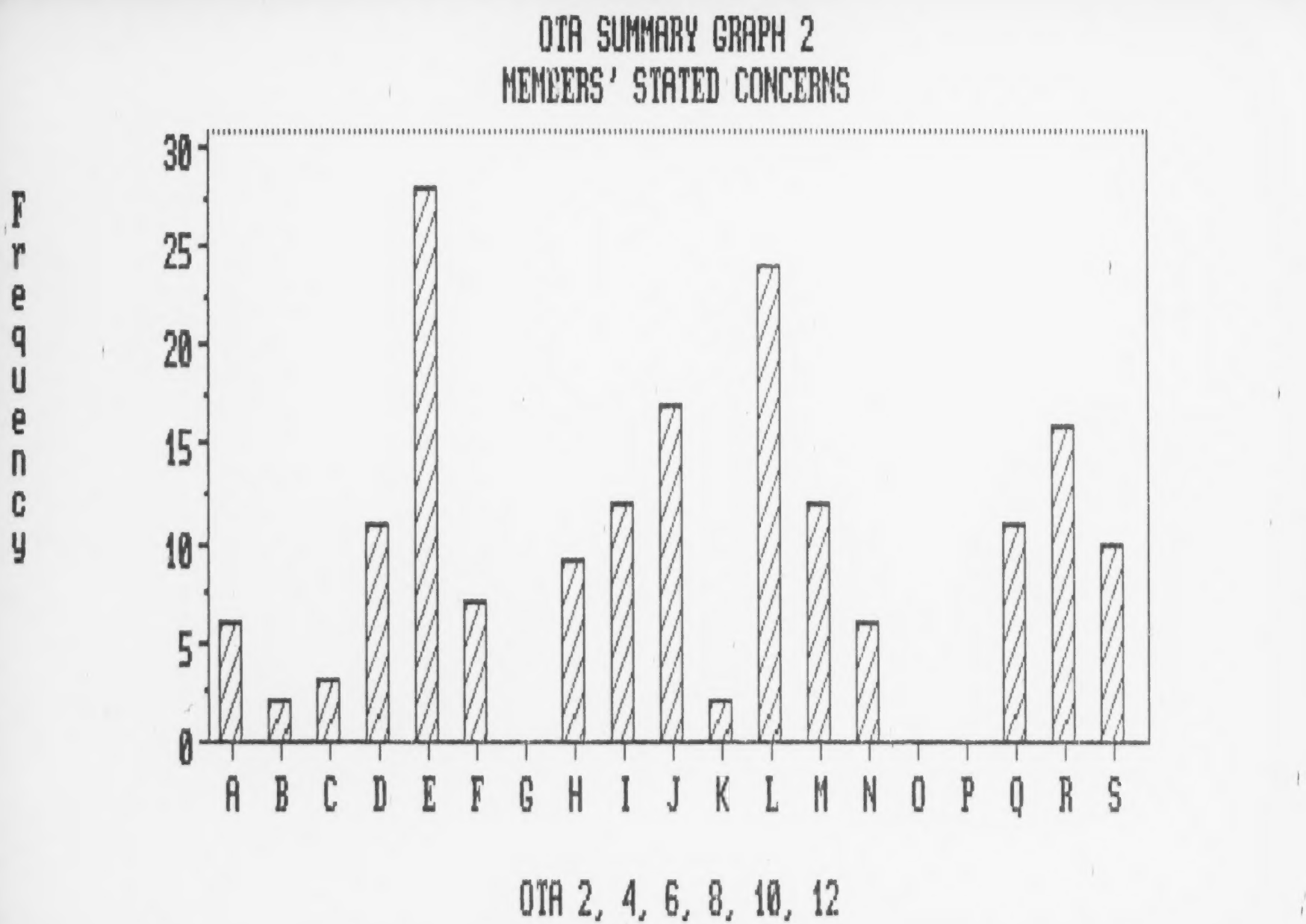
1. Major concerns expressed by witnesses

Three thematic clusters were measured for this question ("Military vs. Civilian," "Big vs. Little," and "Individual Investigator vs. Program vs. Cen-

OTA SUMMARY TABLE 2
Members' Stated Concerns

TABLES	A	B	C	D	E	F	G	H	I	J	K	L
OTA 2	1	1	0	0	11	4	0	5	5	0	0	10
OTA 4	3	1	0	5	1	2	0	1	2	7	0	5
OTA 6	0	0	0	2	0	1	0	1	1	6	0	6
OTA 8	0	0	0	0	0	0	0	0	0	0	1	0
OTA 10	2	0	1	3	15	0	0	1	4	4	1	2
OTA 12	0	0	2	0	1	0	0	1	0	0	0	1
TOTALS	6	2	3	11	28	7	0	9	12	17	2	24
PERCENT	0.03	0.01	0.01	0.06	0.16	0.04		0.05	0.06	0.09	0.01	0.14

M	N	O	P	Q	R	S
1	0	0	0	1	0	1
5	3	0	0	0	5	3
0	0	0	0	1	9	6
0	2	0	0	0	0	0
6	1	0	0	1	0	0
0	0	0	0	8	2	0
12	6	0	0	11	16	10
0.06	0.03			0.06	0.09	0.05


OTA SUMMARY GRAPH 2
MEMBERS' STATED CONCERNS
Frequency
30
25
20
15
10
5
0
A B C D E F G H I J K L M N O P Q R S
OTA 2, 4, 6, 8, 10, 12

ter Grants"). The first two themes were mentioned infrequently by both witnesses and Members, although the third theme figured considerably more often in witnesses' comments and somewhat more often in Members' remarks (cf. OTA Summary Tables 1 & 2 and OTA Summary Graphs 1 & 2).

Among witnesses, there was general support for the established individual investigator mode of research support, if carried out in a competitive, peer-reviewed manner. This was seen as the most efficient and effective way to insure the highest quality, innovative, path-breaking research, and to encourage new researchers in their fledgling careers. Program and center grants, on the other hand, allow greater cross-disciplinary cooperation, as well as facilitating the acquisition, maintenance, and operation of expensive shared equipment and facilities. Such grants also increase agency direction of research, since the individual investigator grant has proven resistant to centralized direction. Both program grants and the more structured center grants allow the funding agency greater ability to channel or direct the research work toward agency goals. Witnesses asserted that program and center grants can also provide an enhanced degree of funding stability, at least in some cases.

However, despite these aspects, center grants were opposed by some witnesses as a major funding mechanism for basic research precisely because of the enhanced outside control such mechanisms provide. While such outside direction might be used profitably in more applied areas, particularly engineering projects, for basic scientific research they were deemed excessively restrictive of the intellectual initiative of individual investigators. Individ-

ual investigator support through established disciplines, under competitive peer-reviewed procedures, is clearly preferable to program or center grants:

> ...I would advocate centers in moderation and only when funding agencies are confident that they have already paid attention to the research in the normal disciplinary areas. I personally believe that no center should ever have the right to make faculty appointments, admit graduate students, or award degrees. These should be the responsibility and prerogative of strong disciplinary departments[E].

Others criticized program and center grants because they tend to concentrate in a few well-known institutions, placing investigators at smaller, less-well-known institutions at a distinct disadvantage in competing for scarce funding [this theme -- big schools vs. smaller schools -- reoccurred often in witnesses' comments throughout these hearings]. Also, agency discretion may be reduced with regard to centers of national prominence and longevity, since reductions or eliminations of funding for such centers -- for whatever reason -- would produce severe dislocations. Alternatives to center funding were put forward, as well:

> The conclusion is obvious: centers can provide more stability and efficiency in the funding of the infrastructure, but only to the extent that the center is continued. <u>It is more effective to fund individual projects, and rely on indirect costs for the necessary sharing, than to establish and subsequently terminate funding for a center</u> (emphasis in original)[B]

2. Major concerns expressed by Members

Members expressed two general concerns about program and center grants. The first was the possibility that such grants would allow universities in the second or third tier to develop their research capabilities, facilities, and personnel, and to become more competitive overall in the race for funding. The other concern was that program and center grants allowed for the clear focusing of research efforts from several disciplines upon specific problems of public urgency, such as public health issues (AIDS, cancer) and environmental problems (acid rain, toxic wastes).

3. Points of agreement/disagreement between witnesses and Members

The first concern about how to improve the standing of smaller schools around the country in competition with a handful of very prestigious universities reoccurs several times in Members' questions, while a concern that scientific research be directed to concrete public policy problems raised by concerned constituents also appears with regularity throughout the hearings. By and large, the witnesses remained sensitive to both concerns, but argued that at least for basic research, program and center grants were not as effective or efficient as individual investigator funding, which maximize the investigator's ability to adapt and change the focus of research as unexpected findings and opportunities appear.

C. Question Three: What selection methods used by the Federal agencies are effective for ensuring the attainment of research

goals? How could they be improved? How would the introduction of new criteria, such as geographic distribution or the weighting of criteria other than "merit," change the selection of institutions, projects, and researchers for support? What innovations or transfers across agencies (e.g., military to civilian) or research areas are needed?

1. Major concerns expressed by witnesses

Five theme clusters were used for this question ("Competitive Peer-Reviewed vs. Non-Competitive Awards," "Facilities Grants vs. Research Project Grants," "Pluralism vs. Centralization," "Scientific Autonomy vs. Political Considerations," and "Merit vs. Additional Criteria"). Witnesses mentioned the first, second, and fifth theme with substantial frequency, especially the second. The other two themes were mentioned considerably less often. Among Members, the first theme was mentioned far more often than any of the other four themes.

With two exceptions in these hearings, witnesses uniformly supported competitive, peer-reviewed procedures for funding basic research, over non-competitive approaches. All witnesses supporting the current peer-review system acknowledged that it is sometimes flawed and occasionally shows unscientific biases; however, each (again, with two exceptions) asserted that competitive peer-reviewed procedures were far and away preferable to any alternative system, especially one in which broadly political considerations play a major role.

The two witnesses who dissented from this otherwise unanimous assessment of the peer-review system did so on different grounds. In one case, a univer-

sity president complained that the existing system of competitive grants actually applies to only a limited range of federal science support, and argued that the practice of "pork barrel" science -- in which universities directly lobby Congress to mandate specific funding decisions outside the peer-review system -- was necessary if "have not" schools were ever to complete successfully with the relatively limited number of major research institutions that putatively regularly garner the lion's share of federal research dollars. The witness did emphasize, however, that such practices were appropriate only for facilities and infrastructural projects, not for specific research projects, for which the peer-review system is best designed.

The other witness critical of the peer-review system as it currently operates argued that it is extremely inefficient, biased against genuine innovation, and riddled with conflicts of interest:

> It is [a] ghastly parody of "fairness" to pretend that stimulating the generation of a number of proposals which is 30 to 50 <u>times</u> the number of awards is anything other than an insane process".

The witness then outlined an alternative system that proposed to factor into specific project funding decisions various measures of the past productivity of the research group or researcher seeking funding.

In discussing the respective merits of facilities grants vs. research project grants, witnesses were also divided. The focal point of dispute was the assertion by one witness that the possession of needed facilities by smaller universities was a prerequisite to attracting first-rate researchers who

could compete with researchers in larger, more prestigious universities. That such facilities might be obtained outside the competitive peer-review system was justified because infrastructural improvements would draw better researchers, thereby producing a general improvement in overall research. Opponents of this view argued that competitive peer-review mechanisms were still more effective and efficient for the distribution of facilities grants, and that there exists little or no connection between the possession of such facilities and a school's ability to attract top-flight researchers. The original critic asserted that this line of reasoning was meant merely to cement the preferred position of a handful of universities in the competition for federal funding.

Concerning the importance of plural vs. centralized funding sources, all witnesses unanimously affirmed that multiple funding sources were crucial to the continued superiority of American science.

Likewise, all witnesses supported a maximum of autonomy for the science community in making decisions internal to the functioning of the scientific enterprise. A number of witnesses, however, attempted to draw a bright line distinction between the science community's autonomous management of internal scientific matters and the Congress' responsibility for establishing broad national priorities for scientific research.

While all witnesses agreed that the scientific merit of research proposals should be the dominant determinant of funding, there was disagreement about how effective the current peer-review process is at determining that merit. Virtually all witnesses rejected specifically factoring various "non-scientific" criteria, such as geographical dispersal, impacts on local eco-

nomic development, etc., into the funding decision process, at least for individual research projects. When the issue was infrastructure, facilities, and equipment, however, some witnesses were more willing to allow non-merit considerations to apply.

2. Major concerns expressed by Members

When considering competitive, peer-reviewed awards, most Members' comments focused upon the perception that the existing system skews awards toward researchers located in a small number of institutions, while thousands of researchers in second and third tier institutions are given insufficient funding:

> Hardly a year goes by when we consider, say, the NSF budget that we don't have complaints from Members...[about] an inadequate geographical distribution; that States or universities located within States...are still not getting what they perceive as a fair shake in the research funds that are distributed. We are all in the Congress -- in the House, 435 -- from various parts of the country. The pressure has been on to do something about that[5].

Other Members complained that the current peer-review system works more as an "old boy" network, rewarding those with the right connections and a skill in preparing grant proposals, rather than picking the scientifically best projects to fund. There will be more discussion of these complaints below.

There was relatively little Member interest in facilities vs. research project funding, except insofar as facilities grants might help some schools become more competitive for project grants.

Concerning scientific autonomy, those Members who commented upon this theme did so largely in connection with complaints about the apparently inequitable distribution of research funding, suggesting that if scientific autonomy worked in a geographically biased fashion, it might need to be amended or altered in some ways.

Those Members who addressed the theme of merit criteria in funding decisions also did so as part of larger concerns about the fairness of the existing peer-review process.

3. Points of agreement/disagreement between witnesses and Members

While most Members expressed general support for some kind of competitive granting procedures for basic scientific research, there was considerable skepticism among several representatives that the current peer-review process worked as well as it was designed to do, and, just as important, as well as the science community claimed. Whether because other Members had approached them as members of the oversight committee, or from their own experiences, some Members complained directly about the apparent maldistribution of research funding, and the difficulties smaller, less-prestigious schools seem to have in obtaining adequate federal research support.

On the other hand, all but two witnesses defended the existing peer-review process. While they acknowledged that occasional failures do happen,

they asserted that no better system for allocating support to the most promising scientific projects exists, and that American predominance in most areas of science depended directly upon the peer-review process. The two exceptions tended to side with Members' concerns about inefficiency and distributional bias in the existing system.

Most Members seemed willing to accept witnesses' assessment concerning the relative values of facilities vs. research project grants. The lack of interest among Members on the issue of scientific autonomy may reflect Members' willingness to accede to the science community's management of internal evaluative procedures free of outside political pressures.

The question of what added criteria, if any, should be applied to funding decisions generated more intense disagreements between witnesses and Members, largely as part of the Members' perceptions of inequitable geographic distribution in the awarding of research funding.

D. Question Four: How can Congress be assured that the science community is attempting to perform research that will be consistent with the stated goals of the programs? In general, the basic research community seeks advances in knowledge, while Congress funds research with an eye toward meeting national goals. Are these views sometimes in conflict?

1. Major concerns expressed by witnesses

Five themes were used for this question ("Efficiency vs. Inefficiency," "Flexibility vs. Rigidity," "Haves vs. Have-Nots," "New Researchers vs. Established Researchers," and "Stability vs. Instability"). The first theme in this

cluster figured most prominently in witnesses' comments, more than twice the frequency of the next most prominent theme. The fourth and fifth themes also appeared often in witnesses' remarks. Among Members, the third theme figured most often, appearing twice as often as the next most frequent theme (see OTA Summary Tables 1 & 2 and OTA Summary Graphs 1 & 2).

For most witnesses, the issue of efficiency hinged upon paperwork demands in the granting process. Not only were the initial paperwork demands extreme, several witnesses complained, but the necessity to renew grants in two or three year intervals also meant that the paperwork virtually never ended. A number of witnesses urged more extended grant periods, of five years or more, just to free researchers of the need to interrupt their research to meet agency demands.

On the question of "Haves vs. Have Nots," most witnesses defended the existing granting system as generally fair, with funding available to any qualified researcher with a high quality research proposal. Moreover, they asserted that however humanly flawed the current system is, none better had been proposed and the existing system is inextricably linked to American scientific preeminence. Not surprisingly, this issue was virtually never first broached by witnesses, but by Members concerned that institutions in their districts were being systematically denied federal funds in favor of other schools and other regions of the country.

All witnesses agreed that it is important to insure that new researchers just beginning their careers are given adequate funding for their research, and all emphasized the need for stability in funding, that rapid changes in

funding levels cause substantial disruptions of research programs that may require several years of sustained effort to achieve success.

2. Major concerns expressed by Members

Members' concerns about efficiency centered on how to assess whether a specific funded project had produced enough useful findings to warrant continued support, especially in an era of restricted budgets. Such concerns, which suggest a need for greater scrutiny of research projects, was mixed with expressions of sympathy from Members for the existing paperwork burden researchers already face.

The issue of a perceived maldistribution of funding under the existing peer-review system elicited the greatest interest among Members. A number spoke of specific universities or research teams which had been denied funding, and of the difficulties that smaller schools have in competing against bigger schools. Especially since the costs of new equipment for cutting edge science had grown so dramatically in recent years, the fear was expressed that smaller schools would never be able to "catch up" with the privileged few. A few Members thought that some form of explicit geographic considerations had already been mandated by NSF's organic legislation, and that the Foundation had not lived up to the demands of the law.

Related concerns about how difficult it is for new researchers to compete for funding against researchers from established laboratories figured in Members' concerns. This worry was related to the larger issue of perceived competitive disadvantage experienced by schools from certain parts of the country.

Members expressed general sympathy for the witnesses' concerns about stability of research funding.

3. Points of agreement/disagreement between witnesses and Members

By a very large margin, the major area of disagreement between witnesses and Members focused upon the Members' sense of an unfair distribution of funding. While no Member specifically used the expression "old boy network," this was clearly how some of them thought the existing peer-review system worked. Virtually all witnesses demurred, arguing that even researchers at smaller schools could compete effectively for funding.

Two witnesses remarked that if certain schools, such as Stanford, Cal Tech, MIT, or Harvard, regularly received larger shares of federal science support, it reflected those institutions' decades-long efforts to become preeminent in research, and that other schools should emulate them. State government, local corporations, and the universities themselves should husband resources, raise funding, hire first-rate researchers, and they, too, would begin to garner larger shares of the research funding pie. Some Members responded that the costs of modern research are so staggeringly high that most institutions, even with substantial state support, could never hope to "break into" the first ranks unless the federal government came to their assistance.

E. Question Five: Have there been clearly articulated goals for the system? Are Federal actions consistent with those goals? How have these goals changed wince 1960? How can Congress, through funding mechanisms or other means, set priorities among

the goals of the research community to accomplish both effective research and, at the same time, its broader societal goals?

1. Major concerns expressed by witnesses

Five theme clusters were used for this question ("Clarity of System Goals vs. Changes since 1960," "Cross-Agency Innovations and Transfers," "Congressional Control of System Goals and Priorities," "State Government, University, & Corporate Contributions," and "Infrastructure Problems"). Neither witnesses nor Members paid much attention to the first two themes. Among the final three themes, witnesses paid most attention to the final one, dealing with infrastructure problems.

The first two themes received virtually no commentary from either witnesses or members. The third theme appeared in 4% of witnesses' comments, and in 6% of Members'. The fourth theme was discussed 8% of witnesses' remarks, and 9% of Members' comments. The fifth theme was referred to in 12% of witnesses comments, but in only 5% of Members.

When witnesses addressed the issue of Congressional control of the research system's goals and priorities, they uniformly supported the general principle that Congress, not the science community, should determine the nation's broad goals and priorities in scientific research. However, each witness also defended the science community's autonomy in determining specific research projects through the peer review process. Thus, while the Congress performs its rightful role in laying out broad national science priorities, they said, its is not the legislature but the science community which should control the specifics of research project selection.

Many witnesses commented on the role of state governments, universities, and corporations in the support of basic research. Some spoke of specific state government programs in support of research at university laboratories, while others described how various corporations cooperate with universities to support specific research programs. All witnesses supported the general concept of cooperative programs involving the science community, federal and state governments, and corporations to support research, infrastructure development, and personnel recruitment and training.

By far, the largest number of witnesses' comments concerned infrastructural problems facing university laboratories. Aging facilities, out-dated equipment, and inadequate training of new science personnel figured in most witnesses' concerns. All witnesses asserted that maintaining American scientific leadership -- along with continuing scientific contributions to American economic competitiveness in the international marketplace -- requires a major infusion of new funding to deal with infrastructure problems. There were a few comments about the infrastructure problems facing smaller colleges, compared to larger, more prestigious institutions, coupled with defenses of specific, non-competitive facilities grants mandated by Congress, although this was a minority position among all witnesses.

2. Major concerns expressed by Members

When discussing Congressional control of the research system's goals and priorities, Members' comments focused on three issues: efficiency in the use of research funds, mission-oriented research support, and the geographic distribution of research funding. Concerning efficiency, some Members expressed

doubts about the peer review system in allocating research funding, along with skepticism about the paper work reporting requirements of governmental funding agencies. A few Members raised the issue of mission-oriented projects, to deal with cancer, AIDS, etc., although none pressed these issues with much vigor. The issue of "haves" vs. "have-nots" figured in Member's complaints that the existing peer review system had failed to adhere to Congress' intent in funding research.

Members expressed general agreement that state governments, universities, and corporations should contribute to meeting the nation's scientific research needs. While Members were generally sympathetic to the problems of infrastructure issues, most Members' references concerned specific states' needs for research facilities and up-to-date research equipment.

3. Points of agreement/disagreement between witnesses and Members

There was substantial agreement between both witnesses and Members concerning Congress' role as general regulator of the nation's science agenda, as well as agreement that state governments, universities, themselves, and corporations should be enlisted in efforts to support scientific research, train personnel, and deal with infrastructure problems. The greatest degree of disagreement between Members and witnesses came during discussions of infrastructure problems, with some Members raising once again their sense of inequity in federal support through the existing peer review system. Smaller, less well known schools, some Members reiterated, lost out in a non-random manner to larger, better-known institutions in the competition for scarce funding.

III. Conclusions

In some ways, the testimony of witnesses and the give-and-take of questioning by Members displayed in these six hearings followed patterns predictable to anyone familiar with the science community/Congressional relationship over the past several years.

As expected, the science community's representatives showed appropriate deference to Congress' role in setting national research goals and priorities, while at the same time defending scientific autonomy in the allocation of funding for specific research projects. Witnesses in general defended the existing peer review system as the best mechanism -- however flawed -- for preserving scientific excellence, and argued against the introduction of "non-merit" criteria, such as geography, potential economic impacts, etc., in the funding decision process. Most witnesses complained about the reporting and paper work burdens of federal funding, blaming most of the existing system's admitted inefficiencies on the government's demand for frequent funding proposals and other clerical requirements. None of the witnesses favored a greater degree of centralization in funding procedures, each asserting that the pluralistic -- if sometimes redundant -- programs currently in place contribute to the freedom, flexibility, and productivity of American science. The witnesses were also unanimous in decrying the state of university laboratories, research facilities, and research equipment, and called for greater federal funding for resolving such infrastructure problems.

There were some disagreements among witnesses when discussing the relative merits of program and center grants, versus individual investigator

grants and about the effectiveness of the existing peer review system. Two witnesses raised serious complaints that peer review as currently practiced is wasteful, inefficient, and unfair to all but a handful of prestigious institutions. There was a heated debate about the appropriateness of individual institutions lobbying Congress directly for facilities support, and the possible detrimental effect of such "pork barrel" practices upon the larger scientific enterprise. While most witnesses condemned such lobbying, two witnesses claimed that the practice, when limited to facilities grants, did not undermine the larger scientific enterprise, and was the only way "have not" schools could hope to eventually compete with the "haves."

Members' concerns often involved the effects of federal funding allocations upon specific states and districts, with several Members complaining the existing peer review system had become an "old boy network," effectively preventing smaller schools from several states from obtaining their "fair share" of federal research funding. There were some heated exchanges concerning the beneficial economic impacts of research funding on local communities, and demands that mechanisms be found to dispense such funding in a more geographically equitable manner. While Members did not suggest that federal science research funds be allocated by specifically geographic formulae (although one Member spoke approvingly of the geographically-based research funding supported by the Department of Agriculture), they did express frustration that the science witnesses had no solutions to offer, other than reliance upon the competitive peer review system. Both witnesses who criticized the peer review system received sympathetic hearings from Members, who raised repeated questions about how to improve the system.

Members also commented critically upon various inefficiencies in the national research effort, dividing their comments between critiques of inefficiencies internal to the science community and inefficiencies imposed by the government. On the whole, there was less emphasis upon "quick payoff" research programs, such as for cancer or AIDS, than might have been expected, although there were frequent references to the contribution of science to U.S. economic competitiveness (but see Mowery & Rosenberg[6] for an extended argument that this position is misdirected).

Members were, on the whole, sympathetic to the general mission of the scientific research community, as well as responsive to several specific complaints raised by witnesses. There was less criticism of the science community than had been heard in previous decades, especially during the late 1960s and 1970s. In large measure this can be attributed to changes in national political priorities during the late 1970s and throughout the 1980s: declining economic performance, greater penetration of the U.S. market by foreign products and foreign manufacturers, and a sense of public worry about the state of the economy had replaced earlier concerns about science's implication in the Viet Nam war, environmental degradation, and other social issues. Rather than picture science as an accomplice -- whether witting or unwitting -- in various social evils, science is depicted in these hearings as an institution critical to important national goals. Testimony and comments showed concern for the efficiency, health, and productivity of the scientific enterprise, leavened with some pointed criticisms that the existing research system continues to display shortcomings and inequities.

As the costs of basic research increase, they -- although sympathetic with the general notion of support for basic research -- desire to see practical applications of research results, and become restive about investments in exotic facilities and costly equipment when the practical pay off is hard to see.

Although scientists remind legislators that it is impossible to predict just which investment in basic research will produce socially useful knowledge, and that indeed many will never produce such knowledge, by coupling continued federal support for basic research to the promise of eventual practical benefits, the science community repeatedly places itself at risk that legislators will demand more specific social returns for the federal money invested. As basic research increases in cost, as facilities require millions and hundreds of millions of dollars, and as the focus of that research seems ever more abstract and distant from practical applications, the tensions between long-term investments in basic research and short-term benefits will necessarily increase. Legislators and scientists, of necessity, operate on quite different time scales, making effective cooperation problematic.

An important additional dissent from the standard arguments for basic research was heard from two witnesses who objected to the existing peer review system. There was considerable sympathy for and resonance with the witnesses' complaints on the part of various Members. As legislators have seen the economic benefits accruing to states and localities capable of attracting high tech industries, and how useful strong science facilities are to attracting such industries, they have come to wonder why major research funding appears to go predominantly to a select set of universities. They hear complaints from

academic administrators in their home states that local researchers are unable to compete against Harvard, Berkeley, and Chicago. Lacking funding for first-rate research facilities, local schools are unable to attract the best new researchers, and are therefore trapped in a vicious cycle. The much vaunted peer review system is called an "Old boy network" in which the "Haves" always out compete the "Have-nots." and Non-merit-related criteria.

The other area of disagreement, more subtle than the preceding issue, was the Members' sympathy with witnesses' complaints about burdensome applications procedures, coupled with Members' concern that mechanisms be found to cut off the funding for research projects that were not productive. There is an unstated contradiction between wanting to reduce the burden of agency demands for information, on the one hand, and the desire for closer scrutiny of unproductive research projects, on the other. The contradiction centers on the concept of accountability, illustrating an ever-present tension between the role of the legislature and the role of the science community.

On the basis of the science community's promise of continued socially useful knowledge, Congress has by and large granted a great deal of autonomy in administering funding, an autonomy they see as threatened by the array of reporting requirements imposed by federal granting agencies. By insisting that only scientists are competent to choose which research projects to pursue, scientists sever the links of accountability to voters that is the core of the legislator's role.

The trust in the science community's ability to manage the funding it receives, to provide the socially useful knowledge it promises, can be shaken

by events and developments within and without the science community. When the public hears of seemingly inane research projects, when universities engage in pork barrel politicking for funding, when the media play up episodes of apparent scientific fraud, public confidence -- and legislators' confidence, too -- in the informal science/government contract can decline dramatically. In those circumstances, legislators want to reassert their authority, reestablish traditional political accountability, and impose additional demands upon the science community which may adversely affect scientific productivity.

To avoid such "outside interference," the science community must find ways of either regularly producing important, practical breakthroughs, or convincing the Congress that esoteric and largely impractical research is so much in the Nation's interest as to justify continued unfettered federal funding. Having so tightly tied the fate of science to the production of social benefits, the science community cannot expect that society will forget science's promises when deciding how to spend the public's money.

Methodological Appendix

The Task Force on Science Policy has produced a thirty-seven volume collection of hearings and background reports, in addition to the Task Force's Final Report (still in preparation as of this writing). Such a massive corpus of transcripts, reports, essays, reprinted articles and news items would be an overwhelming project for anything approaching a thorough quantitative content analysis. To keep this project to a managable size, I formulated, in consultation with the OTA staff, a nineteen item theoretical framework covering issues and concerns considered important and relevant for OTA's study of "Basic Research for the 1990s," which was applied across a six-volume sample of the larger Task Force corpus.

Selecting six volumes of hearings that were both representative of the Task Force materials in general and germane to OTA's concerns required a careful scan of the entire Task Force compendium. I evaluated the hearings for statements, questions, and responses that generally addressed the theoretical framework. Some hearings, of course, could be immediately excluded because their subjects were so distant from the framework. While any sample can be questioned for its representativeness, I do believe that the six volumes selected for this study capture those hearings which dealt most directly with OTA's concerns.

The goal was to find a set of hearings that were extensive enough, and that bore on OTA's concerns, that I would be able to adduce the central tendencies in the remarks, concerns, and interests of both the witnesses and the Members. This is not so rigorous a goal as a formal content analysis, but

rather an effort to present both graphically and narratively the frequency and direction of the policy-relevant interests of the participants. OTA's desire was to assess the kinds of issues considered important by science poicy specialists and by concerned Members, to see where those interests coincide and where they may diverge. Thus, OTA wanted to know how often various themes appeared in both witnesses' and Members' comments, and to get a feel for the affective responses of witnesses and Members when discussing such matters in the give-and-take atmosphere of congressional hearings.

Put OTA Summary Table 4 here

Witnesses' statements, both oral and written, were read to determine the frequency each mentioned the themes captured by the framework. This was followed by a similar reading of questions and answers between witnesses and Members. OTA Summary Table 3 provides a breakdown of witnesses' remarks by academic field and by agency.

Put OTA Summary Table 3 here

The final step, encompassed in this narrative report, is to provide a qualitative assessment of the themes and concerns of both the expert witnesses and the Members in these six hearings. Such analysis, while not reaching the methodological sophistication of a formal quantitative content analysis, can record the cental tendencies of witnesses' and Members' major concerns. The

OTA SUMMARY TABLE 4

01: RESEARCH AREA PROFILES

A: Multidisciplinary mission programs

02: ANALYTIC CATEGORIES

B: Military vs. Civilian
C: Big vs. Little
D: Individual Investigator vs. Program vs. Center Grants

03: SELECTION METHODS

E: Competitive Peer-reviewed vs. Non-Competitive Awards
F: Facilities Grants vs. Research Project Grants
G: Pluralism vs. Centralization
H: Scientific Autonomy vs. Political Considerations
I: Merit vs. Additional Criteria (economics, geography, etc.)

04: CONGRUENCE WITH STATED RESEARCH POLICY GOALS

J: Efficiency vs. Inefficiency
K: Flexibility vs. Rigidity
L: "Haves" vs. "Have Nots"
M: New Researchers vs. Established Researchers
N: Stability vs. Instability

05: RESEARCH SYSTEM GOALS

O: Clarity of System Goals vs. Changes Since 1950
P: Cross-Agency Innovations and Transfers
Q: Congressional Control of System Goals and Priorities
R: State Government, University, & Corporate Contributions
S: Infrastructure Problems

OTA SUMMARY TABLE 3
Witnesses by Discipline and Agency

DISCIPLINES [N]	A	B	C	D	E	F	G	H	I	J	K
PHYSICS [5]	9	0	0	13	12	1	3	1	0	15	0
CHEMISTRY [3]	10	0	1	13	9	1	0	0	0	8	0
BIOCHEMISTRY [1]	0	0	0	3	1	0	0	1	1	2	0
BIOLOGY [1]	0	0	0	0	5	0	0	0	0	1	0
GEOCHEM. [1]	2	2	0	1	0	0	1	0	0	0	0
PHYSIOLOGY [2]	0	0	0	0	1	0	0	0	0	0	0
MEDICINE [2]	0	0	0	0	0	0	0	0	0	0	0
HISTORY [2]	1	0	0	0	0	0	1	1	0	0	0
ECONOMICS [1]	0	0	0	0	0	0	0	0	0	0	0
PHILOSOPHY [2]	4	0	1	0	0	0	1	0	0	0	0
CHEM ENGIN [1]	1	0	0	1	1	0	1	0	0	1	0
PUBLIC ADM. [1]	0	0	0	0	0	0	0	0	0	0	0

AGENCIES [N]	A	B	C	D	E	F	G	H	I	J	K
UNIVERSITY [15]	23	2	2	45	34	8	10	13	9	35	7
AAU [2]	0	0	1	0	2	0	1	0	0	0	0
NAS [2]	3	0	1	3	3	0	1	2	0	0	0
NIH [3]	0	0	0	1	0	0	0	1	0	0	0
OSTP [1]	0	0	0	0	0	0	0	0	0	0	0
NON-PROFIT [1]	0	0	0	0	0	0	0	0	0	0	0
CORPORATE [3]	2	0	0	1	0	0	0	1	0	0	0
ONR [1]	1	0	0	0	1	0	0	0	0	0	0
NSF [1]	0	0	0	0	0	0	0	0	0	0	0
SANDIA [1]	2	0	0	0	1	0	0	0	0	0	0
OTA [1]	0	0	0	0	0	0	0	0	0	0	0
MEDIA [1]	0	0	0	3	0	0	0	0	0	0	0

L	M	N	O	P	Q	R	S
2	4	7	0	0	0	5	9
0	5	6	0	0	0	1	12
1	1	0	0	0	0	0	0
0	1	0	0	0	0	0	1
3	0	1	0	0	1	0	1
2	0	0	0	0	0	3	0
0	1	0	0	0	0	5	5
2	0	0	0	0	1	0	0
0	0	0	0	0	4	0	0
0	0	2	0	0	0	1	0
3	6	4	0	0	0	1	3
0	0	0	0	0	0	0	0

L	M	N	O	P	Q	R	S
8	16	22	0	0	4	11	28
0	0	1	0	0	0	0	0
0	1	0	0	0	1	0	7
1	2	0	0	0	2	0	1
2	0	0	0	0	0	5	5
2	0	0	0	0	0	9	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

goal was not only to accumulate frequency counts across the nineteen theme inventory, but to determine the range of witnesses' and Members' concerns and points of agreement and difference between them.

Specific scoring of witnesses and Members for each hearing follows:

Put OTA Table 1 and Graph 1 here

Put OTA Table 2 and Graph 2 here

Put OTA Table 3 and Graph 3 here

Put OTA Table 4 and Graph 4 here

Put OTA Table 5 and Graph 5 here

Put OTA Table 6 and Graph 6 here

Put OTA Table 7 and Graph 7 here

Put OTA Table 8 and Graph 8 here

Put OTA Table 9 and Graph 9 here

Put OTA Table 10 and Graph 10 here

Put OTA Table 11 and Graph 11 here

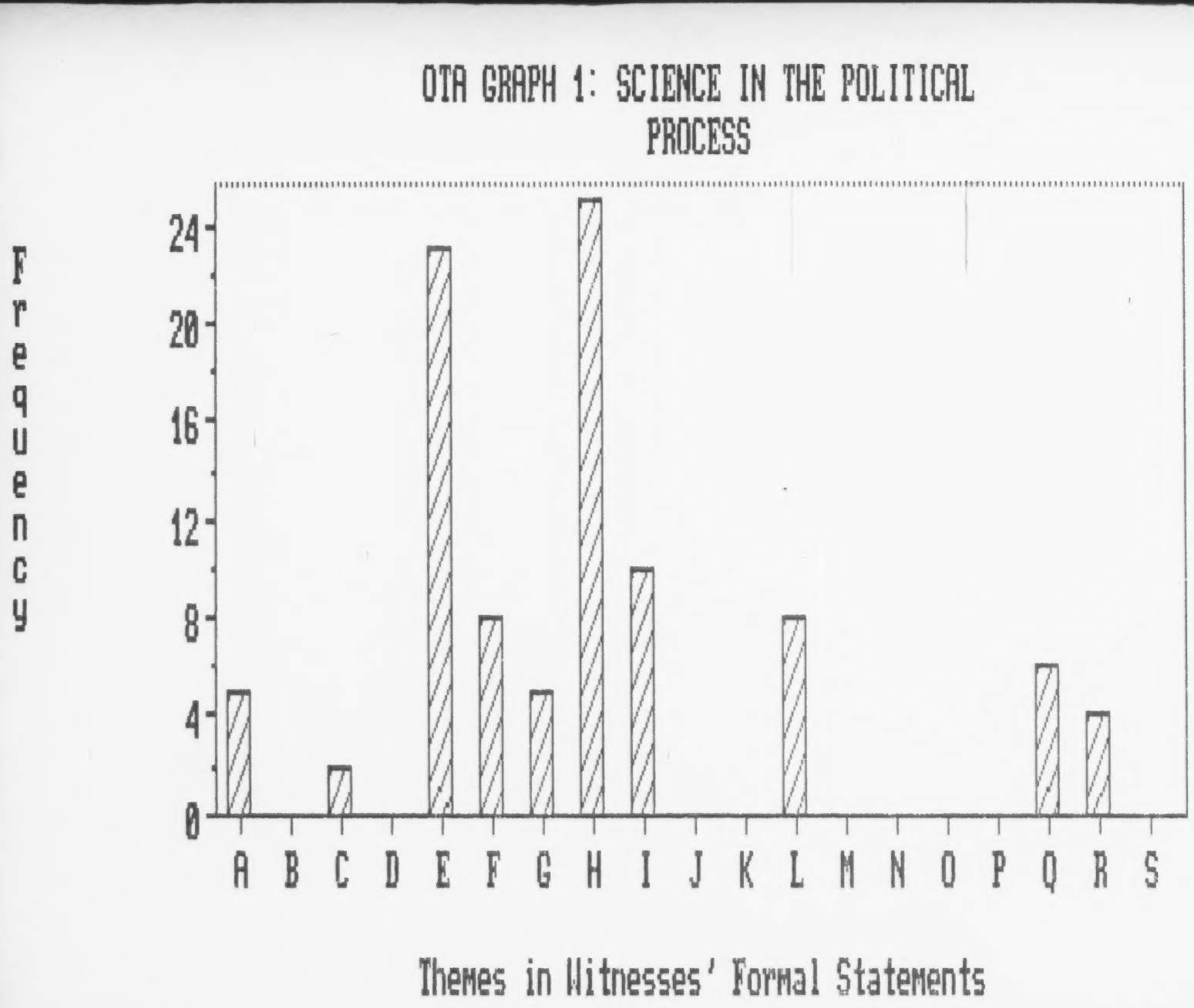
Put OTA Table 12 and Graph 12 here

OTA TABLE 1: SCIENCE IN THE POLITICAL PROCESS

Formal Statements by Witnesses

WITNESS	A	B	C	D	E	F	G	H	I	J	K	L
HASKELL					8		1	6	1			
SPROULL	2		1		3	2	1	2	4			
SILBER	2				5	4	1	5	1			6
ROSENZWEIG			1		6	2	2	8	2			
KEVLES	1				1			4	2			2
TOTALS	5	0	2	0	23	8	5	25	10	0	0	8

M	N	O	P	Q	R	S
				1		
				2	2	
					2	
				3		
0	0	0	0	6	4	0


OTA GRAPH 1: SCIENCE IN THE POLITICAL PROCESS
Frequency
24
20
16
12
8
4
0
A B C D E F G H I J K L M N O P Q R S
Themes in Witnesses' Formal Statements

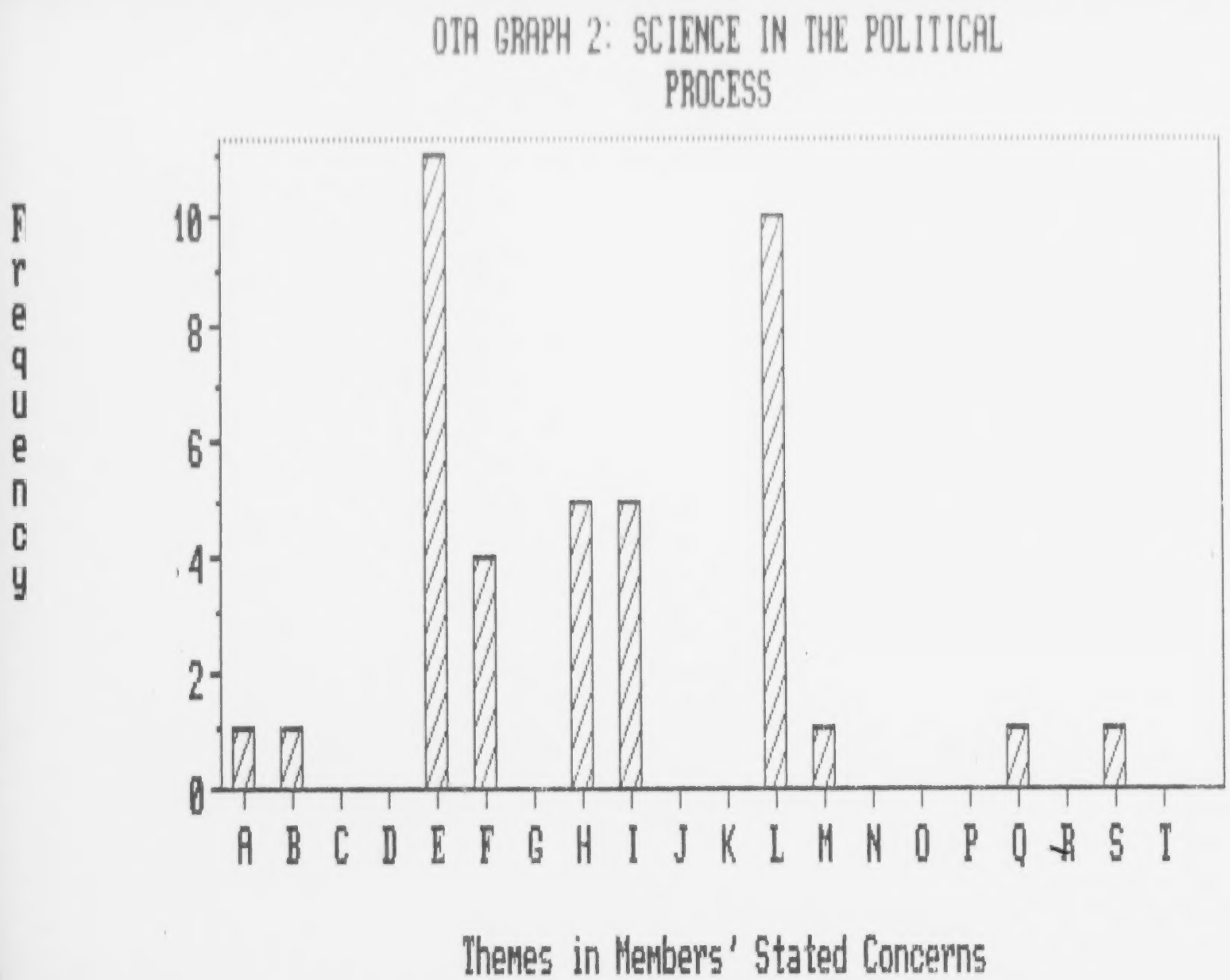
OTA TABLE 2: SCIENCE IN THE POLITICAL PROCESS
Members' Stated Concerns & Witnesses Responses in Colloquies

Themes	A	B	C	D	E	F	G	H	I	J	K	L
MEMBERS	1	1			11	6		5	5			10

WITNESSES	A	B	C	D	E	F	G	H	I	J	K	L
HASKELL	1				3			4	1	1		1
SPROULL		1							1			3
SILBER					2	3			1			1
ROSENZW.					5	2		1	1	1		
KEYLES					1	1		1	1	1		
TOTALS	1	1	0	0	11	6	0	6	5	3	0	5

M	N	O	P	Q	R	S	T
1				1		1	

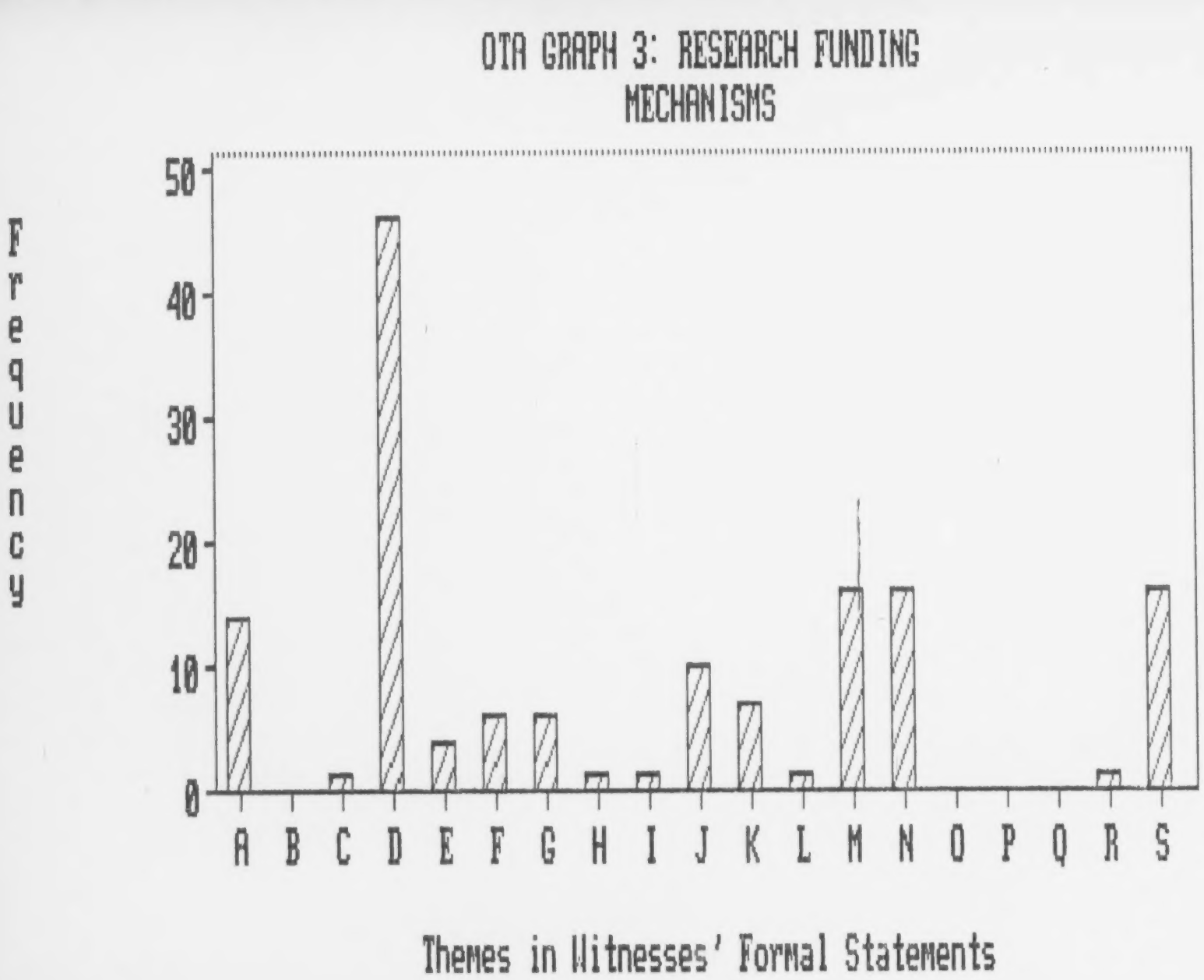
M	N	O	P	Q	R	S	T
1							
1				2	1	1	
1							
1				1	1		
				2			
3	0	0	0	5	2	1	0


OTA GRAPH 2: SCIENCE IN THE POLITICAL PROCESS
Frequency
10
8
6
4
2
0
A B C D E F G H I J K L M N O P Q R S T
Themes in Members' Stated Concerns

OTA TABLE 3: RESEARCH FUNDING MECHANISMS

	A	B	C	D	E	F	G	H	I	J	K	L
PINGS	1			17	1	4	1			1	7	
DOUGLAS				7	1			1	1	2		1
EDEL	5			9	1	1	2			3		
WHITESIDES	8		1	13	1	1	3			5		
TOTALS	14	0	1	46	4	6	6	1	1	10	7	1

M	N	O	P	Q	R	S
6	4				1	7
1						
3	6					2
6	6					7
16	16	0	0	0	1	16


OTA GRAPH 3: RESEARCH FUNDING MECHANISMS
Frequency
50
40
30
20
10
0
A B C D E F G H I J K L M N O P Q R S
Themes in Witnesses' Formal Statements

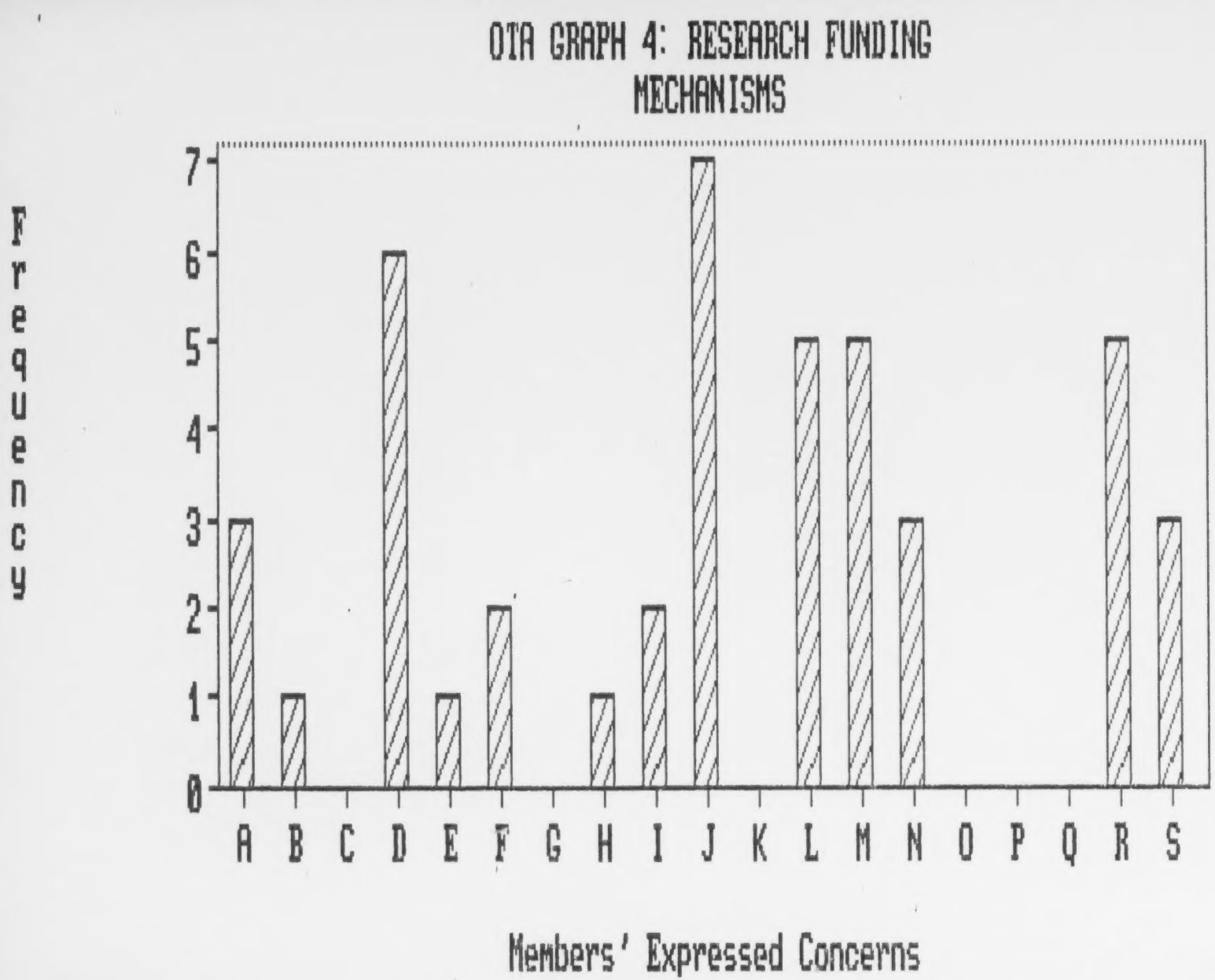
OTA TABLE 4: RESEARCH FUNDING MECHANISMS
Members' Stated Concerns & Witnesses' Responses in Colloquies

WITNESSES	A	B	C	D	E	F	G	H	I	J	K
MEMBERS	3	1		6	1	2		1	2	7	

WITNESSES	A	B	C	D	E	F	G	H	I	J	K
PINGS	2			3	2						
DOUGLAS	1			2						4	1
FEEL				3	1						
WHITESIDES	4			3	2						
TOTALS	7	0	0	10	5	0	0	0	0	4	1

L	M	N	O	P	Q	R	S
5	5	3				5	3

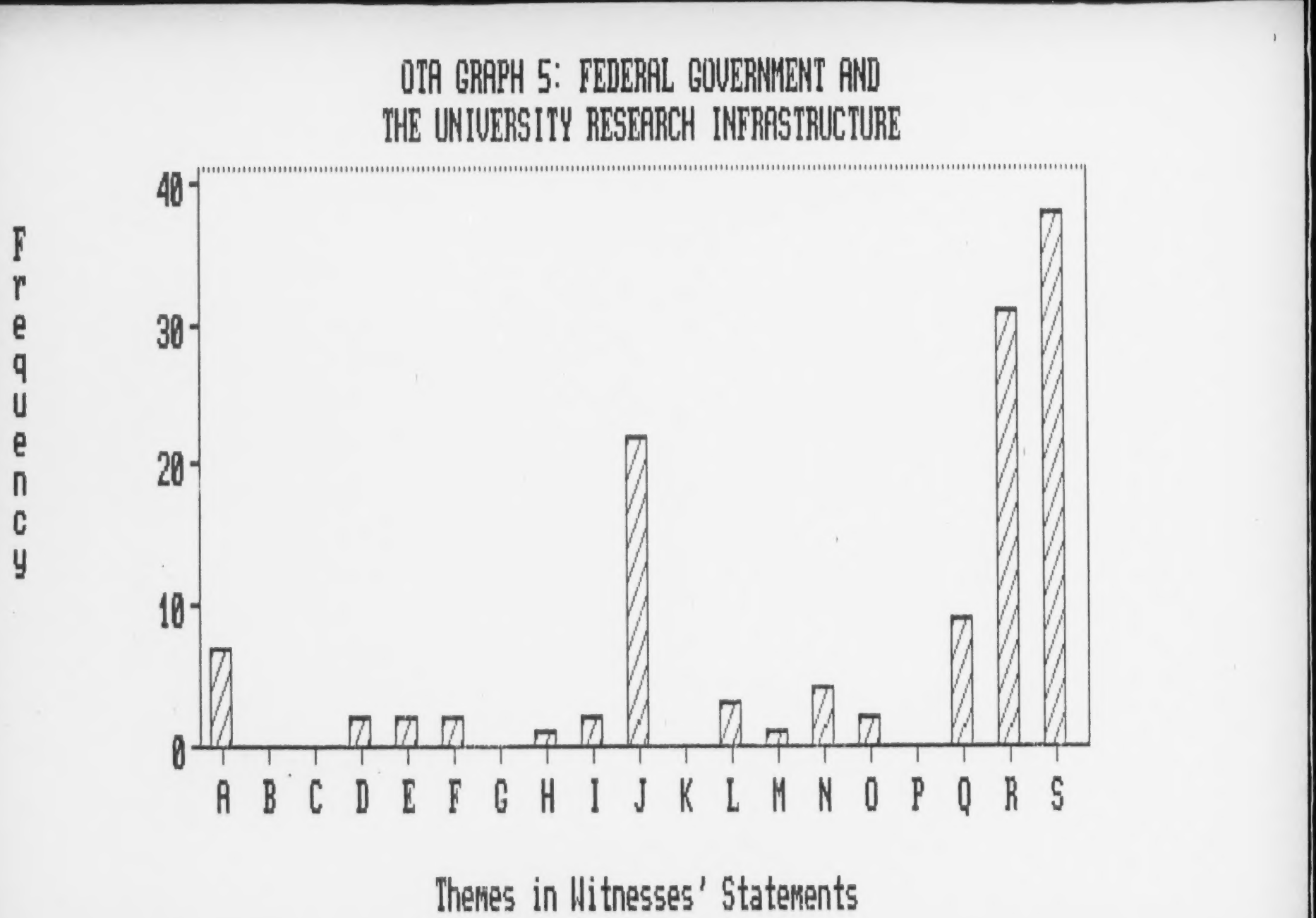
L	M	N	O	P	Q	R	S
1	1					2	1
1	1						
5	5	1					
1	1						1
9	9	1	0	0	0	2	2


OTA GRAPH 4: RESEARCH FUNDING MECHANISMS
Frequency
0
1
2
3
4
5
6
7
A B C D E F G H I J K L M N O P Q R S
Members' Expressed Concerns

OTA TABLE 5: THE FEDERAL GOVERNMENT AND THE UNIVERSITY RESEARCH INFRASTRUCTURE
Formal Statesments by Witnesses

WITNESSES	A	B	C	D	E	F	G	H	I	J	K
HEALY										2	
GORSON	7										
HOLLANDER											
HENSLEY										3	
SMITH											
ARROW				1	1	2		1	1	6	
LANGENBERG					1						
ZDANIS				1		-				4	
KENT										5	
CHAUDARI											
TOTALS	7	0	0	2	2	2	0	1	2	22	0

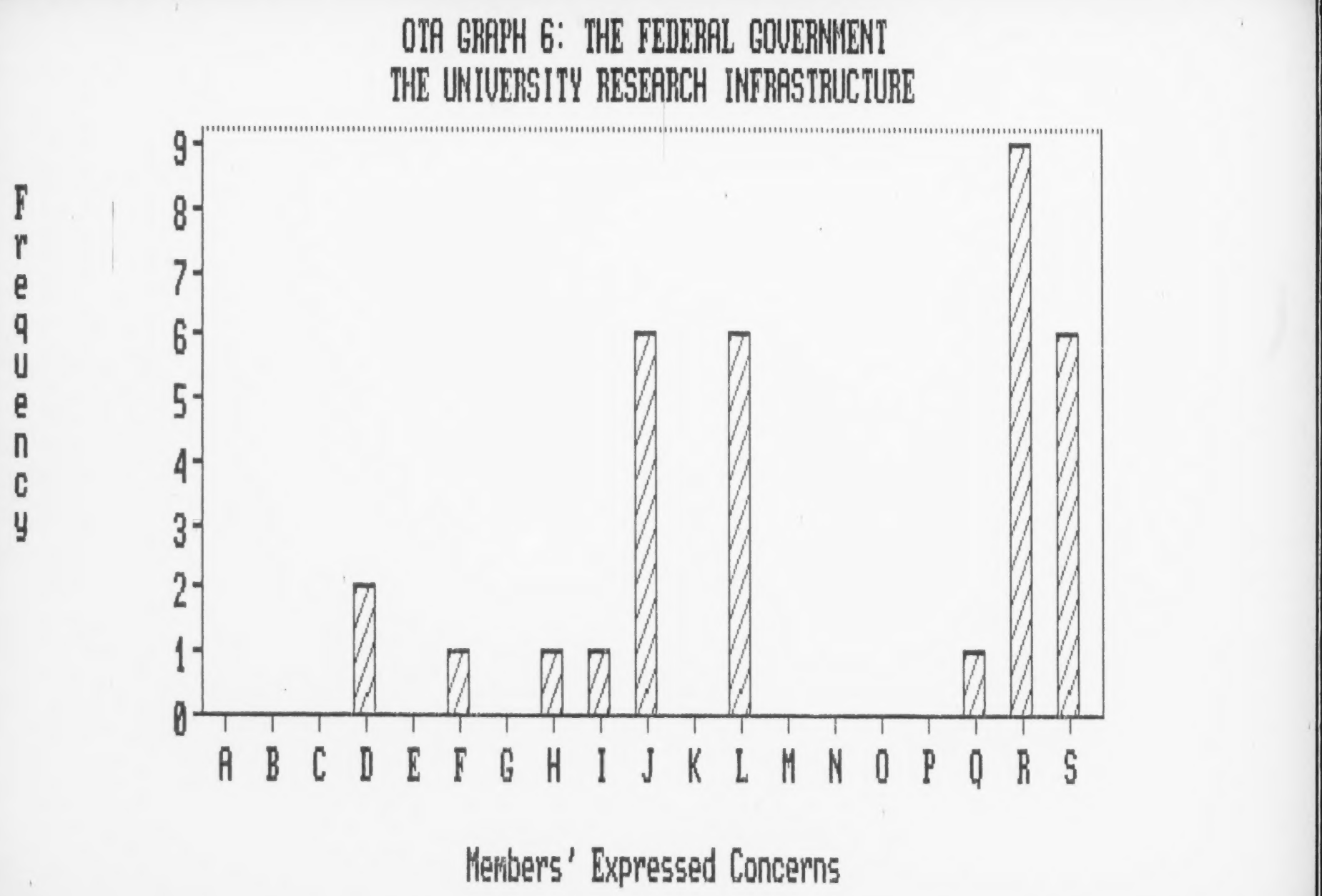
L	M	N	O	P	Q	R	S
						5	5
						11	6
						1	4
2					9	1	
	1	1				6	5
1		1	2			1	9
		2				1	3
						3	3
						2	3
3	1	4	2	0	9	31	38


OTA GRAPH 5: FEDERAL GOVERNMENT AND
THE UNIVERSITY RESEARCH INFRASTRUCTURE
Frequency
40
30
20
10
0
A B C D E F G H I J K L M N O P Q R S
Themes in Witnesses' Statements

OTA TABLE 6: UNIVERSITY RESEARCH INFRASTRUCTURE
Members' Concerns & Witnesses' Responses in Colloquies

	A	B	C	D	E	F	G	H	I	J	K
MEMBERS				2		1		1	1	5	
WITNESSES											
HEALY											
GORSON				2							
HOLLANDER											
HENSLEY										3	
SMITH											
SPROW				1						1	
LANGENBERG										1	
ZDANIS						1			2	3	
HUNT				1							
CHAUDARI				1							
TOTALS	0	0	0	5	0	1	0	0	2	8	0

L	M	N	O	P	Q	R	S
6					1	9	6
					1	1	1
	1					2	
						2	1
							2
						1	
							1
2							
						1	1
						3	1
						2	
2	1	0	0	0	1	12	7

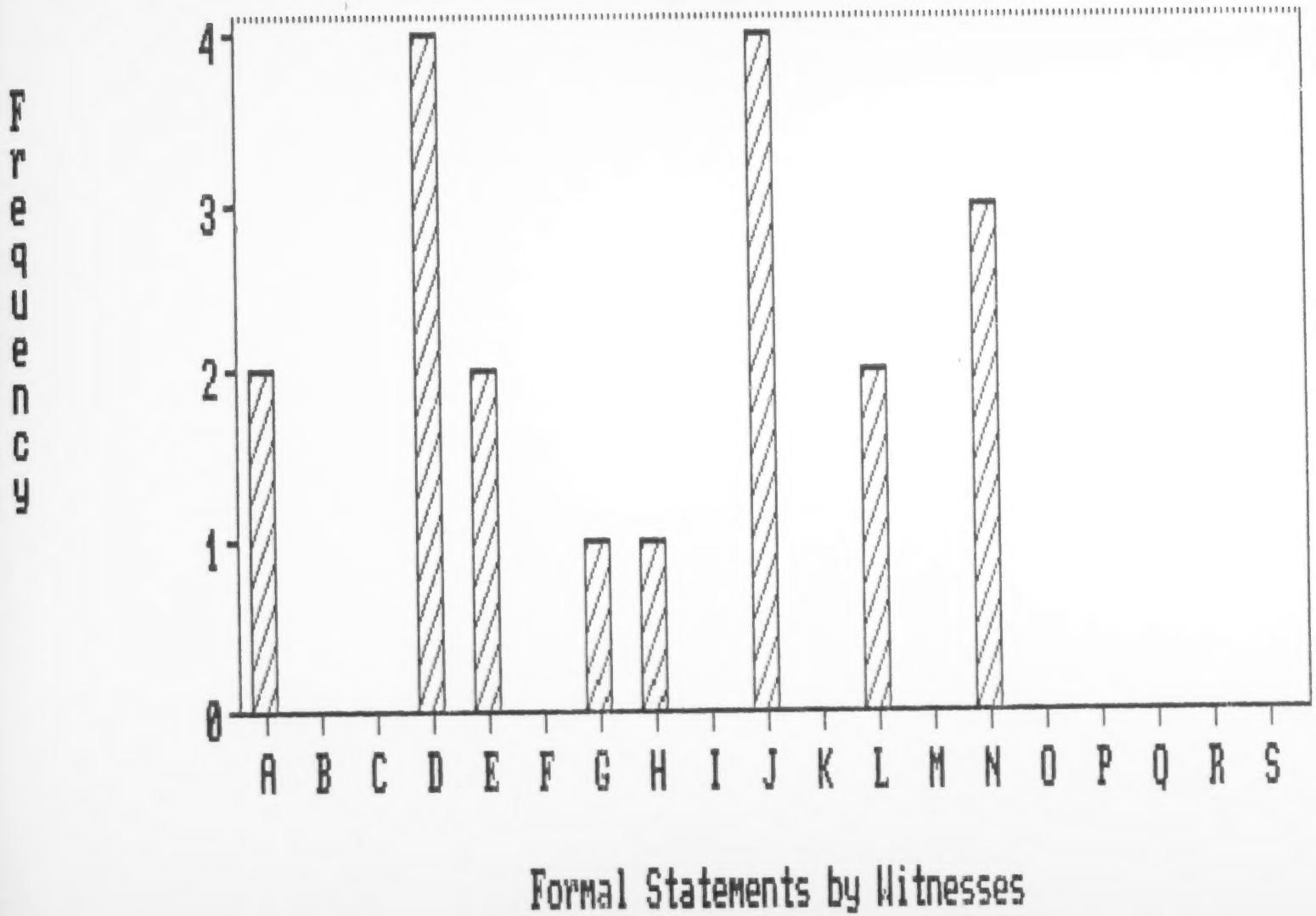

OTA GRAPH 6: THE FEDERAL GOVERNMENT
THE UNIVERSITY RESEARCH INFRASTRUCTURE
Frequency
0
1
2
3
4
5
6
7
8
9
A B C D E F G H I J K L M N O P Q R S
Members' Expressed Concerns

OTA TABLE 7: NATIONAL RESEARCH FUNDING LEVELS
Formal Statements by Witnesses

WITNESSES	A	B	C	D	E	F	G	H	I	J	K	L
BROOKS				4	2		1	1		4		2
DAILY												
MENDRICK												
RESCHER	2											
GARFIELD												
HILL												
TOTALS	2	0	0	4	2	0	1	1	0	4	0	2

M	N	O	P	Q	R	S
	1					
	2					
0	3	0	0	0	0	0

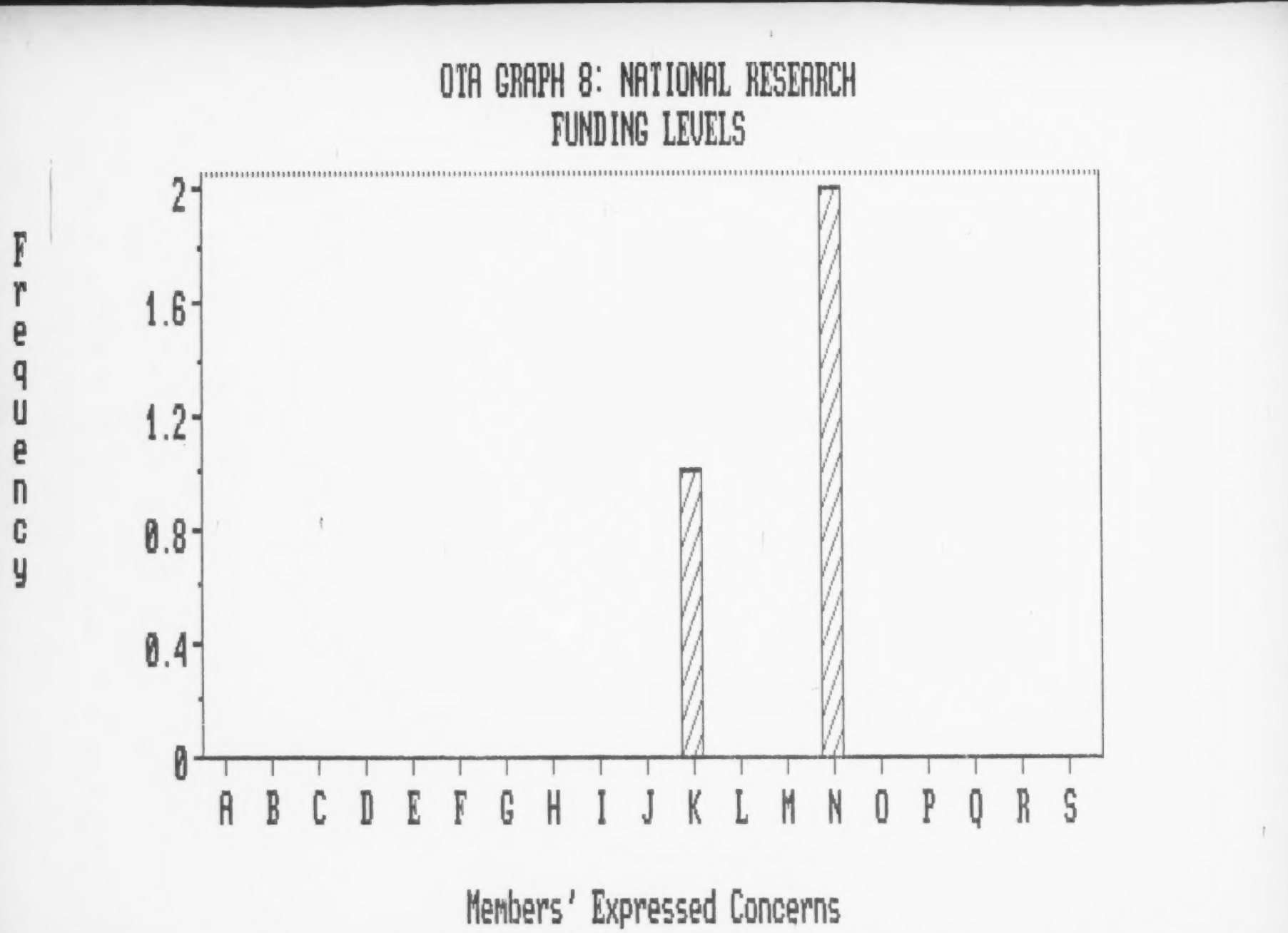
OTA GRAPH 7: NATIONAL RESEARCH FUNDING LEVELS



OTA TABLE 8: NATIONAL RESEARCH FUNDING LEVELS
Members' Concerns & Witnesses' Responses in Colloquies

	A	B	C	D	E	F	G	H	I	J	K	L
MEMBERS											1	
WITNESSES												
BROOKS												
BAILEY											1	
KENDRICK												
REICHER												
GARFIELD												
HILL												
TOTALS	0	0	0	0	0	0	0	0	0	0	1	0

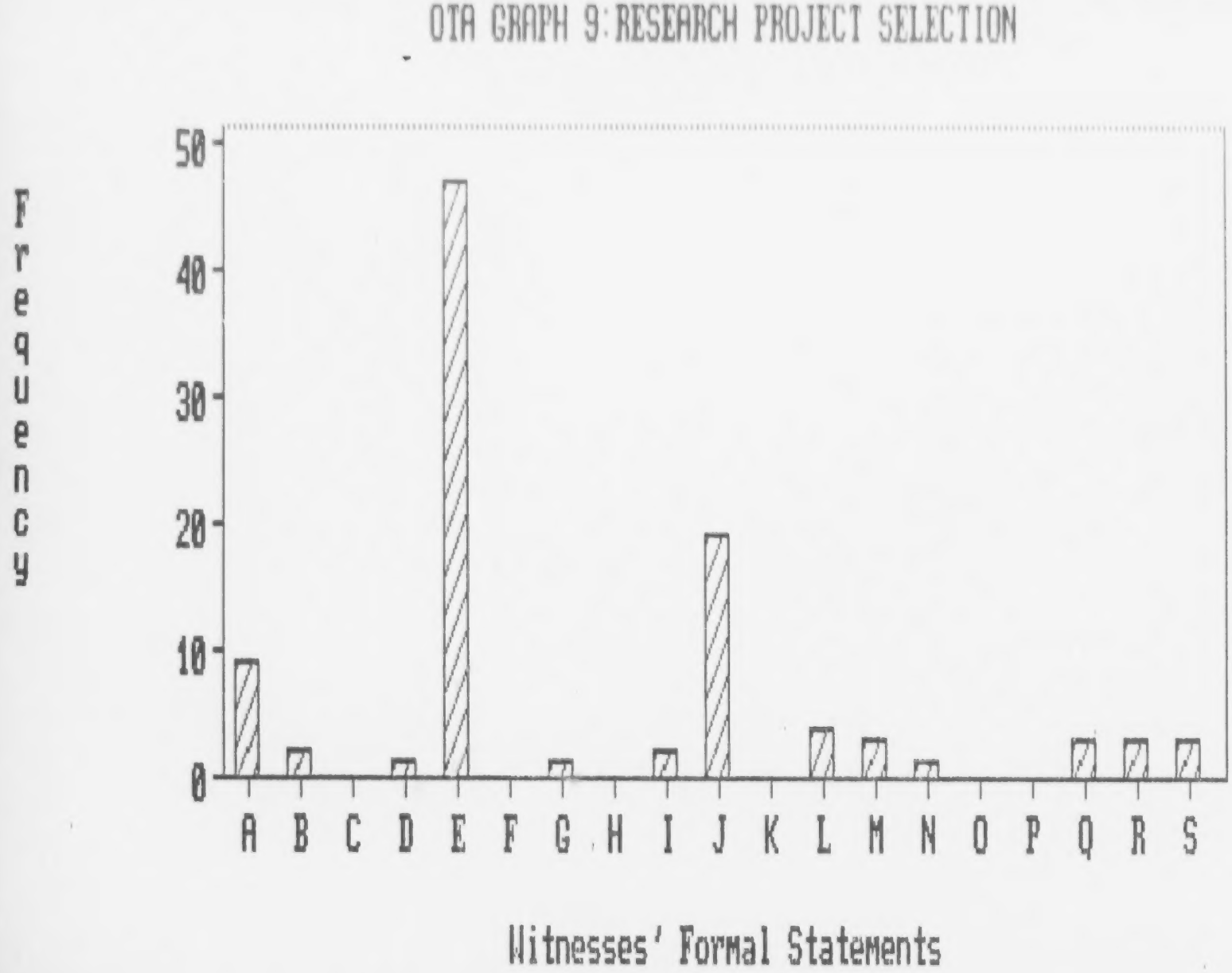
M	N	O	P	Q	R	S
	2					
	1					
	1					
				1		
0	2	0	0	1	0	0


OTA GRAPH 8: NATIONAL RESEARCH
FUNDING LEVELS
Frequency
2
1.6
1.2
0.8
0.4
0
A B C D E F G H I J K L M N O P Q R S
Members' Expressed Concerns

OTA TABLE 9: RESEARCH PROJECT SELECTION
Witnesses' Formal Statements

WITNESSES	A	B	C	D	E	F	G	H	I	J	K
ROY	2	2		1	5		1			5	
HIRSCHSTEIN					2					1	
KANE	3				5					1	
MOSS	1				1						
CLUTTER					5					1	
REPLINGER					2						
CLARKE					1				2		
ERLENKMAN	2				1						
McCARTY											
SUMNEY	2				8					9	
ARMSTRONG											
OUISENBERRY											
TOTALS	9	2	0	1	47	0	1	0	2	18	0

L	M	N	O	P	Q	R	S
2		1			1		1
	1						
	1						1
	1						1
					2		
2						3	
4	3	1	0	0	3	3	3


OTA GRAPH 9: RESEARCH PROJECT SELECTION
Frequency
50
40
30
20
10
0
A B C D E F G H I J K L M N O P Q R S
Witnesses' Formal Statements

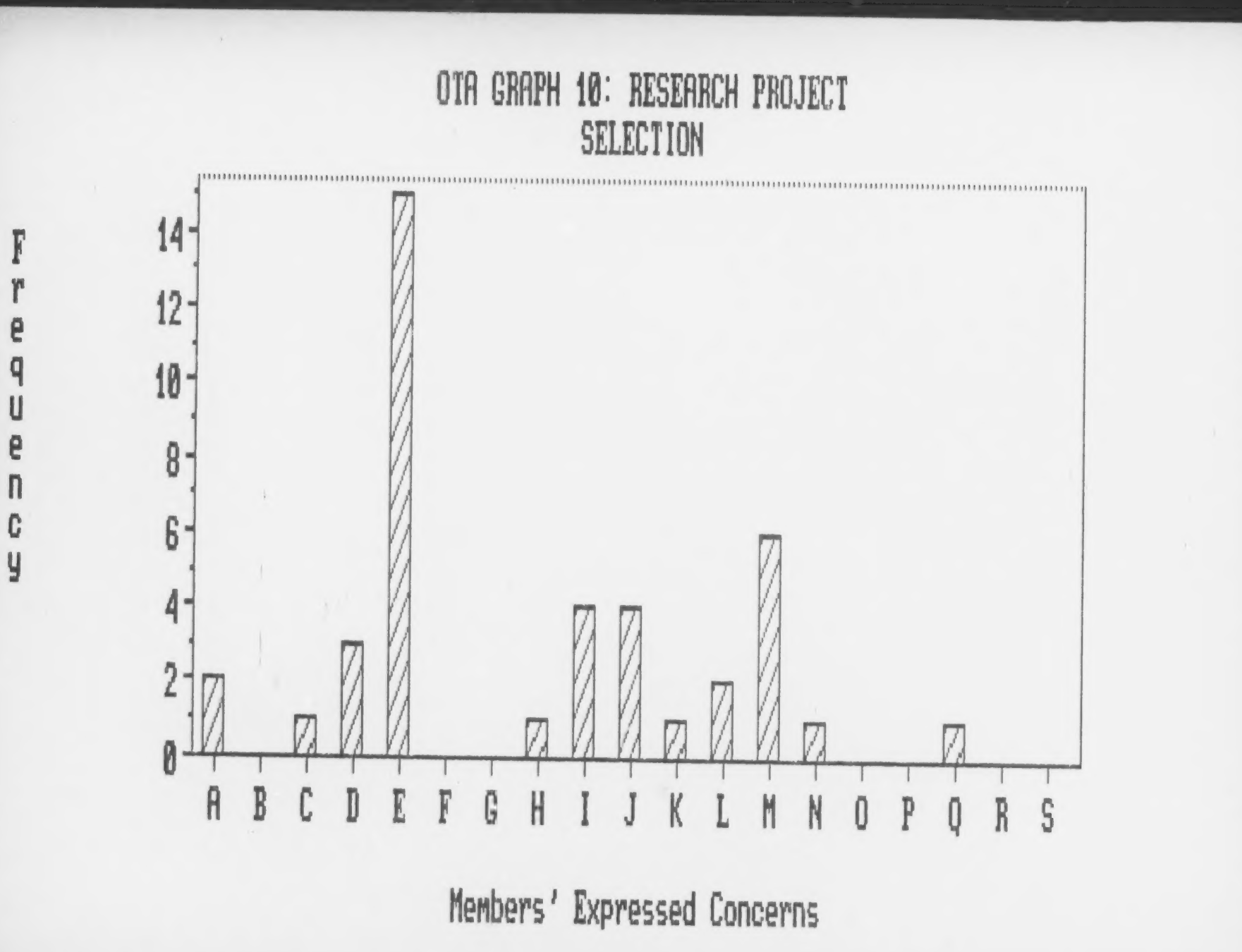
OTA TABLE 10: RESEARCH PROJECT SELECTION
Members' Concerns & Witnesses' Responses

	A	B	C	D	E	F	G	H	I	J	K
MEMBERS	2		1	3	15			1	4	4	1
WITNESSES											
ROY			1		3						
KIRSHSTEIN					4			2	4	1	
KANE	1										
MOSS	1				3						
CLUTTER	2									2	
BERLINGER										1	
CLARKE					1						
PRINKMAN				2							
McCARTY					1						
SUMNEY											
ARMSTRONG											
QUISENBERRY											
TOTALS	4	0	1	2	12	0	0	2	4	4	0

L	M	N	O	P	Q	R	S
2	6	1			1		

2	1	1
1	1	1

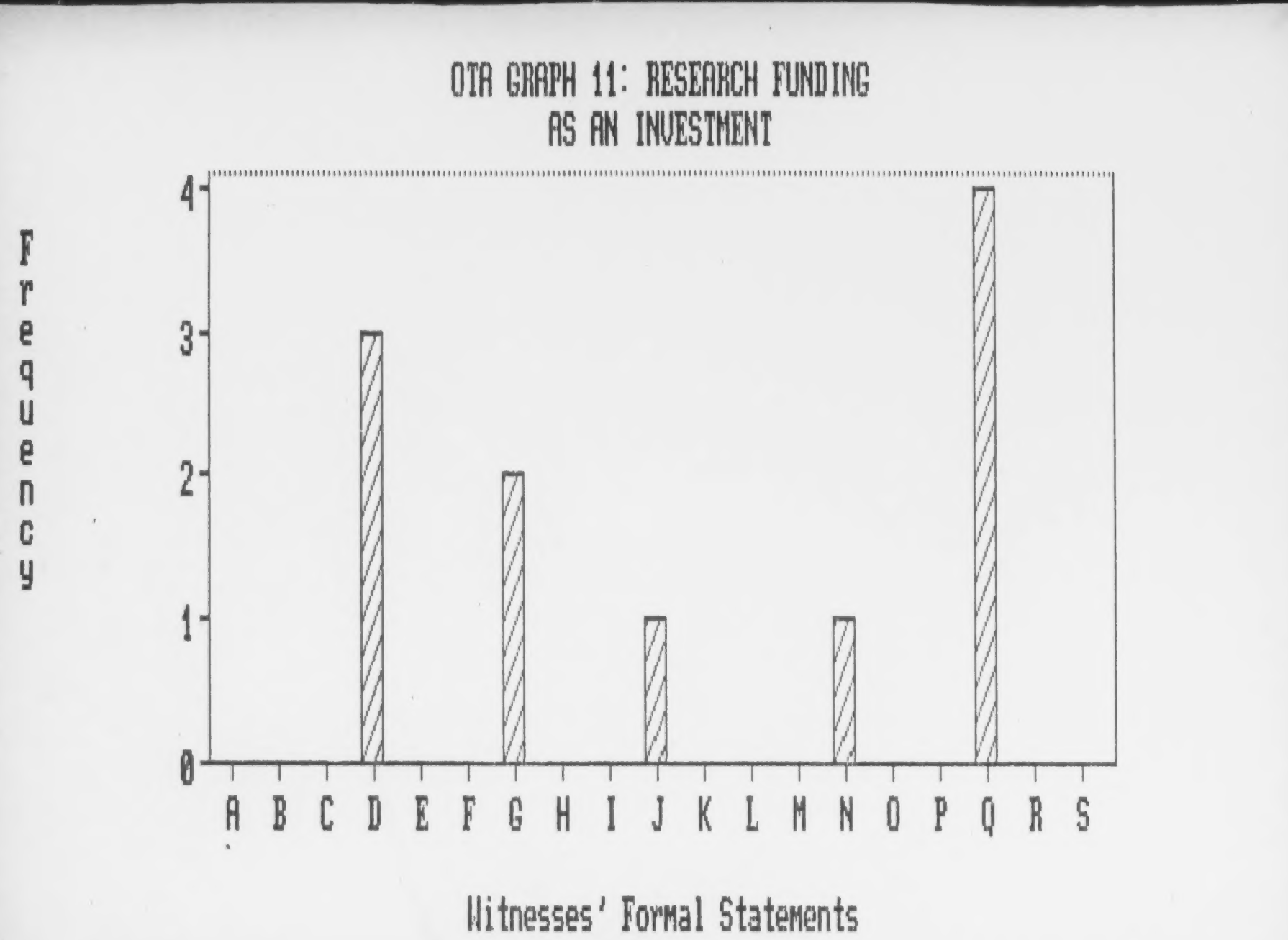
2


OTA GRAPH 10: RESEARCH PROJECT SELECTION
Frequency
0
2
4
6
8
10
12
14
A B C D E F G H I J K L M N O P Q R S
Members' Expressed Concerns

OTA TABLE 11: RESEARCH FUNDING AS AN INVESTMENT
Witnesses' Formal Statements

WITNESSES	A	B	C	D	E	F	G	H	I	J	K
NAISMITH							2				
MOWERY											
TANNER											
BAGLEY											
GRILICHES											
GEIREG											
LEONTIEF											
FOSTER											
ELTINGE											
PHILLIPS											
ROY				3							
SHAPLEY										1	
MOGEE											
HALLION											
TOTALS	0	0	0	3	0	0	2	0	0	1	0

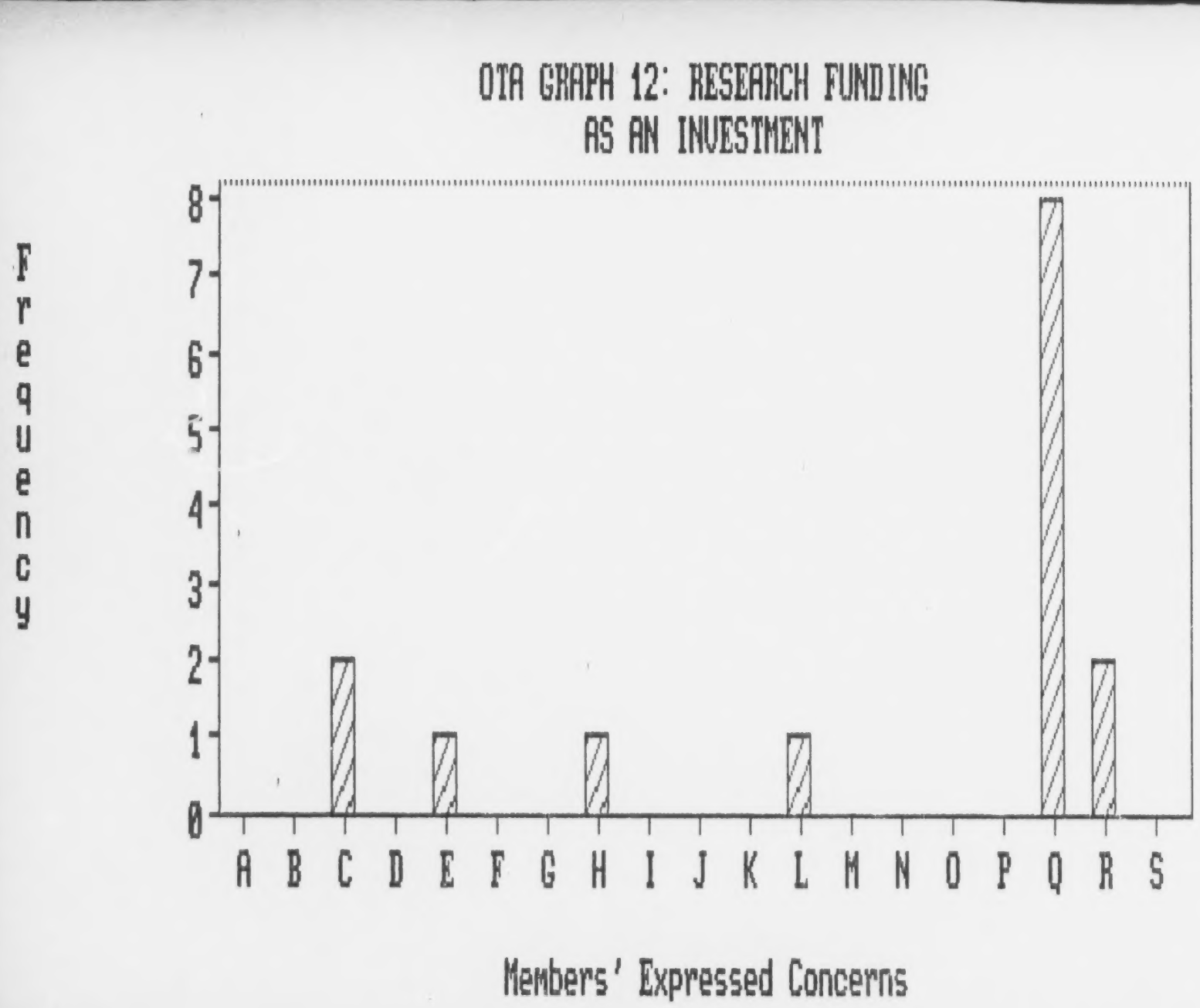
L	M	N	O	P	Q	R	S
					4		
		1					
0	0	1	0	0	4	0	0


OTA GRAPH 11: RESEARCH FUNDING
AS AN INVESTMENT
Frequency
4
3
2
1
0
A B C D E F G H I J K L M N O P Q R S
Witnesses' Formal Statements

OTA TABLE 12: RESEARCH FUNDING AS AN INVESTMENT
Members' Concerns & Witnesses' Responses in Colloquies

	A	B	C	D	E	F	G	H	I	J	K
MEMBERS			2		1			1			
WITNESSES											
NAISMITH											
MOWERY											
TANNER											
BAGLEY											
CRILICHES											
SCHERER											
LEONTIEF											
FOSTER											
SLINGS											
PHILLIPS					1						
ROY											
SHAPLEY											
MCGEE											
HALLION											
TOTALS	0	0	0	0	1	0	0	0	0	0	0

L	M	N	O	P	Q	R	S
1					3	2	
						1	1
					2		
		1					
					1		
					1		
						1	
					1		
						1	
2							
2	0	1	0	0	5	3	1


OTA GRAPH 12: RESEARCH FUNDING
AS AN INVESTMENT
Frequency
0
1
2
3
4
5
6
7
8
A B C D E F G H I J K L M N O P Q R S
Members' Expressed Concerns

References

[1]. Whitesides, George M. 1986. Statement. Research Funding Mechanisms. Hearings before the Task Force on Science Policy of the Committee on Science and Technology, House of Representatives. U.S. Congress. 99th Congress, 2d Session. Science Policy Study -- Hearings Volume 16. March 12, 13, 19, 20. Pg. 131.

[2]. Pings, Cornelius J. 1986. Statement. Research Funding Mechanisms. Hearings before the Task Force on Science Policy of the Committee on Science and Technology. House of Representatives, U.S. Congress. 99th Congress, 2d Session. March 12, 13, 19, 20. Pg. 52.

[3]. Ebel, Marvin E. 1986. Science Policy Task Force Testimony on Research Funding Mechanisms. Research Funding Mechanisms. Hearings before the Task Force on Science Policy of the Committee on Science and Technology. House of Representatives, U.S. Congress. 99th Congress, 2d Session. March 12, 13, 19, 20. Pg. 126.

[4]. Roy, Rustum. 1986. Testimony of Professor Rustum Roy, the Pennsylvania State University, before the House Science and Technology Committee, April 8, 1986. Research Project Selection. Hearings before the Task Force on Science Policy of the Committee on Science and Technology. House of Representatives, U.S. Congress. 99th Congress, 2d Session. April 8, 9, 10. Pg. 21.

[5]. Fuqua, Don. 1986. Science in the Political Process. Hearings before the Task Force on Science Policy of the Committee on Science and Technology. House of Representatives, U.S. Congress. 99th Congress, 1st Session. June 25, 26. Pg. 43.

[6]. Mowery, David C. & Nathan Rosenberg. 1989. Technology and the Pur-

suit of Economic Growth. Cambridge, England: Cambridge University Press.